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(54) Position sensing probe

Sensor zur Abtastung der Position

Sonde de palpage de position

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Description

This invention relates to a probe used for example on a coordinate positioning machine, to measure the position or contour of a surface.

Coordinate positioning machines are known to comprise a head supported for movement in mutually perpendicular directions relative to a support structure on which a workpiece is supportable, and means for measuring the position of the head relative to the support structure in the respective three dimensions. The probe typically comprises a stylus supported on a support assembly for movement from a rest position in three mutually perpendicular directions, and means for measuring the position of the stylus relative to the head in the respective three directions.

In use the probe is secured to the head of the machine and, in a typical operation, the head is moved to a predetermined position in which a stylus secured to the support assembly engages a point on the workpiece in such a way that the stylus is displaced relative to the head. Then the sum of the outputs of the respective measuring means defines the position of the stylus at that point relative to the support structure of the machine. The dimensions of the workpiece are derivable from the sums pertaining to a plurality of such points.

DE 3234471 discloses a measuring probe in which the displacement of the stylus relative to the housing is measured by a plurality of opto-electronic scale reading apparatus, where the sensors are mounted on the movable stylus support assembly.

EP-A-0 422 530, falling within the terms of Article 54(3) EPC, shows an arrangement in which XYZ stylus movement is translated into up/down movements of elements of the stylus support assembly. Body mounted sensors opposite scales on the elements transduce these up/down movements.

The present invention provides a probe for use on a coordinate positioning machine in measuring the position or contours of a surface comprising a fixed structure, the probe being as defined in claim 1.

Embodiments of the invention will now be described by way of example, and with reference to the accompanying drawings wherein:

Fig. 1 is a sectional elevation of the probe.

Fig. 2 is a section on the line I-II in Fig. 1.

Fig. 3 is a section on the line III-III in Fig. 1.

Fig. 4 is a section on the line IV-IV in Fig. 2.

Fig. 5 is a section on the line V-V in Fig. 3.

Fig. 6 is a view similar to Fig. 1 but shows a modification.

Fig. 7 is a section on the line VII-VII in Fig. 6.

Fig. 8 is a section on the line VIII-VIII in Fig. 6.

Fig. 9 shows a modification to Figs 1 and 6;

Fig. 10 is a section on line X-X in Fig. 9; and

Fig. 11 is an enlarged sectional detail of Fig. 1.

The probe generally denoted 10, is described with reference to mutually perpendicular directions X,Y,Z. The probe has a fixed structure, provided by a housing 10, and connectable to the head 12 of a machine. A stylus 14, is supported by an assembly 15 which permits movement of the stylus relative to the housing 12 in each of the X, Y and Z directions. Specifically, the stylus-supporting assembly 15 comprises a first member 16, fixedly connected to housing 12, and having a plane surface 18 extending in the XY plane. A second member 20, having a plane surface 22, is retained against the first member 18 by a pair of Samarium Cobalt magnets 24 which act either on the second member (if it is of ferromagnetic material) or on ferromagnetic elements on the second member. The second member 20 is supported for motion relative to the first member in all directions in the XY plane by means of an air bearing 26 (Fig.4) formed between the adjacent plane surfaces 18 and 22 of the first and second members 16 and 18. The air bearing is fed with compressed air through a supply duct 28. Further, the second member 20 is supported against rotation relative to the first member 16 by a spring bellows 30 (Fig. 1) connected between the second member 20 and a flange 32 provided on the housing 12. The bellows 30 may also be used to bias the second member 20 against, and into a rest position relative to (with respect to the X and Y directions) the first member 16. To this end the bellows 30 may be supplied with compressed air via a duct 34. Bias into the rest position of the second member is also assisted by tension springs 36 connected between a post 38 secured to the second member 20 and posts 40 on the first member 16.

The second member 20 is adapted to support a third member 42 (to which the stylus is connectable) for movement in the Z direction by an air bearing 48 formed between adjacent plane surfaces 50A,B and 52A,B of the second and third members 20,42. The air bearing 48 is fed with compressed air through channels 54, provided in the body of the second member 20 and connected to the bearing 26. The bearings 26 and 48 are thus supplied from the same duct 28. This arrangement obviates the need for example for air-pipe connections between the housing 12 and second member 20 which due to their stiffness would restrict movement of the second member 20. The surfaces 52A,B of the third member 42 are held against the surfaces 50A,B of the second member 20 by Samarium Cobalt magnets 56 located in the second member 20, and the third member 42 is sup-

ported against rotation about the Z direction by the surfaces 50A and 52A being arranged to extend in an XZ plane and the surfaces 50B and 52B to extend in a YZ plane as shown in Fig. 3. The third member 42 is biased into a rest position with respect to the Z direction by a pair of opposing springs 58 (Figs. 3,5) connected between the members 20 and 42. The third member 42 is adapted to have the stylus 14 secured thereto.

In operation, the head 12 is moved relative to the workpiece so as to engage the free end of the stylus 14 with a workpiece 60 and displace the stylus 14 from its rest position by an amount within the range of movement of the members 20,42 relative to the members 16,20, respectively. The displacement of the stylus 14 from its rest position in the X,Y or Z directions is measurable by opto-electronic transducers 62,64,66, respectively. The transducer 62 comprises a scale 62A and a read head 62B mounted respectively on the members 20 and 16. The transducer 64 has a correspondingly mounted scale 64A and read head 64B wherein the lines of the scale 62A are spaced in the X direction while the lines of the scale 64A are spaced in the Y direction for measuring of the stylus displacement in these two directions. The transducer 66 has a scale 66A and a read head 66B mounted respectively on the member 20 and 42 for measuring displacement of stylus 14 in the Z-direction.

In a modification (Figs. 6,7 and 8) the bellows 30 of Fig. 1 is replaced by a spring device 70 comprising a pair of planar springs 72,74 secured to the respective ends of a frusto-conical tube 76. The spring 72 (Fig. 7) is made of resilient sheet material and has slots 78 so arranged that an inner part 72A of the spring 72, (being the part secured to the tube 33), is capable of universal pivotal motion (in a manner akin to a gimbal) relative to an outer part 72B of the spring 72, the outer part being secured to the housing 10. The spring 74 has generally the same construction as the spring 72 including inner and outer parts 74A,74B but in this case the outer part 74B is secured to the adjacent end of the tube 76 while the inner part 74A is secured to an post 80 on the member 20 extending through a clearance hole 82 in the member 16. The springs 72,74 thus perform the function of opposing rotation of first member 26 while allowing translation thereof in the X and Y directions.

Further the magnets 24 of Figs 1 to 4 are replaced by a tension spring 84 extending within the tube 76 and connected between the members 16,20 so as to urge the surfaces of the air bearing 26 into engagement in opposition to the air pressure in this bearing. The spring device 70 and the spring 76 also co-operate to bias the member 20 into a central rest position in the XY plane.

Regarding the member 42, the magnets 56 of Figs. 1 to 4 are replaced by a pair of springs 86 and a pair of springs 88, all connected between the members 20,42 so as to urge the surfaces 50A,B and 52A,B of the air bearings 48 into engagement in opposition to the air pressure in this bearing. The springs of the pair 86 may be arranged between a common point 86A on the member 42 and spaced apart points 86B,86C on the member 20 so that the force of these springs has a component in the X direction to react the air pressure in this bearing 48 and a component in the Z direction such that the two springs co-operate to bias the member 42 into a rest position in respect of the Z-direction. The springs 88 are arranged in the same way as the springs 86.

An alternative arrangement for preventing rotation of the second member 20 is illustrated in Figures 9 and 10. A bracket 90 is connected to the housing 10 via two pairs of parallel planar springs 92A,B and 94A,B extending in mutually perpendicular directions. The bracket 90 is fixedly connected to the post 80, and spring 84 assists retention of the surface 22 of the first member 20 against the surface 18 of the first member 16 as before. The springs 92A,B and 94A, B may buckle and bend to enable movement of the bracket 90 (and therefore the second member 20) in an XY plane, as well as acting to prevent rotation of the bracket 90 (and therefore also the second member 20) relative to the first member 16 by virtue of their inelasticity in the direction of their length.

From the point of view of the control system of the machine, it is desirable that the masses of the second and third members 20,42 should be low and that the masses that need to be moved in any of the three dimensions should be as nearly as possible the same. It will be seen that, in the probe illustrated, the masses to be moved in the X and Y directions are the same, i.e. are constituted by the members 20 and 42. Regarding the Z direction, which involves only the member 42, the mass of this member is necessarily less than that of the combined masses of both the members 20,42 involved in the X,Y motion. However, the member 20 may be made of a lighter material than the member 42 so that the combined mass of the members 20, 42 is not substantially greater than the mass of the member 42. Alternatively, both members 20,42 may be made of very light material so that their combined or separate masses do not show a substantial difference as far as the control system of the machine is concerned. An example of a light material is the honeycomb material shown in Fig. 9 which provides a light but stiff structure. Such material is preferably made of steel or other material (e.g. ceramics) having the ability to provide the hard and smooth surface finish necessary for the air bearings.

The air bearings 26,48 represent a means for virtually frictionless support for the movable parts 20,42. As shown at 28 in Fig. 4, the entry of the compressed air into the bearings 26,48 is via the first member 16 so that no tubes are necessary between relatively movable parts and hysteresis due to such tubes is avoided. As an alternative to the air supply being brought to the bearings 26,48) via ducts 28 and 54 respectively the supply may be provided, via the bellows 30 (the air being fed to the bearings 26,48 from the upper or movable end of the bellows 30).

As shown in Fig. 1, the read heads are mounted on

the first member 16 so that no cables are necessary between the relatively movable first and second members 16,20. In the example illustrated, the read head 66B (Figs. 1,3) is mounted on the second member 20 but any cables to this read head can be brought away from the member 20 via the post 38 and the springs 36.

It is however possible, to mount all three transducer read heads on the housing 12, by providing the scale 66A on the interior of third member 42, and read head 66B in register with the scale on the end of flange 32.

The bearings 26 and 48 are shown as air bearings, preferred because of the exceedingly low friction afforded by such bearings. The bearings may however be provided by other means such as, for example, oil bearings, thin layers of PTFE on the surfaces 18 and 22 (such layers should be sufficiently stiff to retain a desired degree of stiffness between the surfaces 18 and 22), or ball bearings provided between the surfaces 18 and 22. Where ball bearings are used the balls may be either free standing, with e.g. a diaphragm provided at the edges of the surfaces 18 and 22, or trapped in a cage.

In the illustrated embodiments, the first member 16 is fixedly connected to the housing 10, and Z-axis movement of the stylus is provided by the third member 42 being moveable relative to the second member 42 in the Z direction. It is however possible to mount the first member for movement relative to the housing 10 (in e. g. the X direction) for example in a manner similar to the mounting of the third member 42 on the second member 20. In this case, the first plane surface 18 of the first member 16 would extend in the YZ plane and the second member 20 would be free to move relative to the first member 16 in all directions in this plane.

Claims

1. A probe for use on a coordinate positioning machine in determining the position or contour of a surface, the probe comprising a fixed structure (12) by which the probe may be connected to the head of a coordinate positioning machine, and a stylus supporting member (42) for supporting a stylus (14), the supporting member (42) being moveable in at least first and second perpendicular directions relative to the fixed structure (12), the probe further comprising first and second transducers (64,66) for transducing movement of said supporting member (42) in said first and second directions, said first and second transducers (64,66) comprising:

   first and second scales (64A,66A) having lines extending in perpendicular directions;

   reading means (64B,66B) in respect of each said scale (64A,66A), for reading each of said scales (64A,66A) in a direction perpendicular to the lines of each said scale (64A,66A) thereby to measure displacement of said supporting member (42) relative to said fixed structure (12);

   characterised in that:

   said first scale (64A) is coupled to said supporting member (42) for movement therewith in said first direction, and said second scale (66A) is coupled to said supporting member (42) for movement therewith in said second direction, and in that said reading means (64B,66B) are provided on the fixed structure (12), the first and second transducers (64,66) thereby acting directly between the fixed structure (12) and the first and second scales respectively the alignment of the scale lines thereby determining the direction in which the transducers measure said displacement.

2. A probe according to claim 1 comprising three scales (62A,64A,66A) and three reading means (62B,64B,66B) arranged to measure displacement of the supporting member (42) in three mutually perpendicular directions.

Patentansprüche

1. Eine Sonde zur Verwendung an einer Koordinatenpositionierungsmaschine beim Bestimmen der Position oder Kontur einer Oberfläche, wobei die Sonde eine feste Struktur (12), durch welche die Sonde mit dem Kopf einer Koordinatenpositionierungsmaschine verbunden werden kann, und ein Tasterstützglied (42) zum Stützen eines Tasters (14) umfaßt, das Stützglied (42) in wenigstens ersten und zweiten senkrechten Richtungen relativ zur festen Struktur (12) bewegbar ist, die Sonde weiter erste und zweite Transducer (64, 66) umfaßt, um eine Bewegung des Stützgliedes (42) in den ersten und zweiten Richtungen umzuwandeln, und die ersten und zweiten Transducer (64, 66) umfassen:

   erste und zweite Skalen (64A, 66A) mit sich in senkrechten Richtungen erstreckenden Linien, und

   Lesemittel (64B, 66B) bezüglich jeder Skala (64A, 66A), um jede der Skalen (64A, 66A) in einer Richtung senkrecht zu den Linien jeder Skala (64A, 66A) zu lesen und dadurch eine Verschiebung des Stützgliedes (42) relativ zur festen Struktur (12) zu messen,

   dadurch gekennzeichnet,
   daß die erste Skala (64A) an das Stützglied (42) zur Bewegung mit diesem in der ersten Richtung gekoppelt ist, und die zweite Skala (66A) an das Stützglied (42) zur Bewegung mit diesem in der zweiten

Richtung gekoppelt ist, und daß die Lesemittel (64B, 66B) auf der festen Struktur (12) vorgesehen sind, wobei die ersten und zweiten Transducer (64, 66) dadurch jeweils direkt zwischen der festen Struktur (12) und den ersten und zweiten Skalen wirken und die Ausrichtung der Skalenlinien dadurch die Richtung bestimmt, in welcher die Transducer die Verschiebung messen.

2. Eine Sonde nach Anspruch 1, mit drei Skalen (62A, 64A, 66A) und drei Lesemitteln (62B, 64B, 66B), die angeordnet sind, um eine Verschiebung des Stützgliedes (42) in drei wechselseitig senkrechten Richtungen zu messen.

Revendications

1. Une sonde pour utilisation sur une machine à positionner les coordonnées lors de la détermination de la position ou du contour d'une surface, la sonde comprenant une structure fixe (12) grâce à laquelle la sonde peut être connectée à la tête d'une machine à positionner les coordonnées, et un élément de support d'aiguille (42) pour supporter une aiguille (14), l'élément de support (42) pouvant être déplacé dans au moins des premier et deuxième sens perpendiculaires par rapport à la structure fixe (12), la sonde comprenant encore des premier et deuxième capteurs (64, 66) pour capter le mouvement dudit élément de support (42) dans lesdits premier et deuxième sens, lesdits premier et deuxième capteurs (64, 66) comprenant:

des première et deuxième échelles (64A, 66A) ayant des repères s'étendant dans des sens perpendiculaires:

des moyens de lecture (64B, 66B) relativement à chacune desdites échelles (64A, 66A), pour la lecture de chacune desdites échelles (64A, 66A) dans un sens perpendiculaire aux repères de chacune desdites échelles (64A, 66A) pour mesurer ainsi le déplacement dudit élément de support (42) par rapport à ladite structure fixe (12);

caractérisé en ce que:

ladite première échelle (64A) est accouplée audit élément de support (42) afin de se déplacer avec ce dernier dans ledit premier sens, et ladite deuxième échelle (66A) est accouplée audit élément de support (42) afin de se déplacer avec ce dernier dans ledit deuxième sens, et en ce que lesdits moyens de lecture (64B, 66B) sont fournis sur la structure fixe (12), les premier et deuxième capteurs (64, 66) agissant ainsi directement entre la structure fixe (12) et les première et deuxième échelles respectivement, l'alignement des repères d'échelle déterminant ainsi le sens dans lequel les capteurs mesurent ledit déplacement.

2. Une sonde conformément à la revendication 1 comprenant trois échelles (62A, 64A, 66A) et trois moyens de lecture (62B, 64B, 66B) arrangés pour mesurer le déplacement de l'élément de support (42) dans trois sens mutuellement perpendiculaires.

Fig.1.

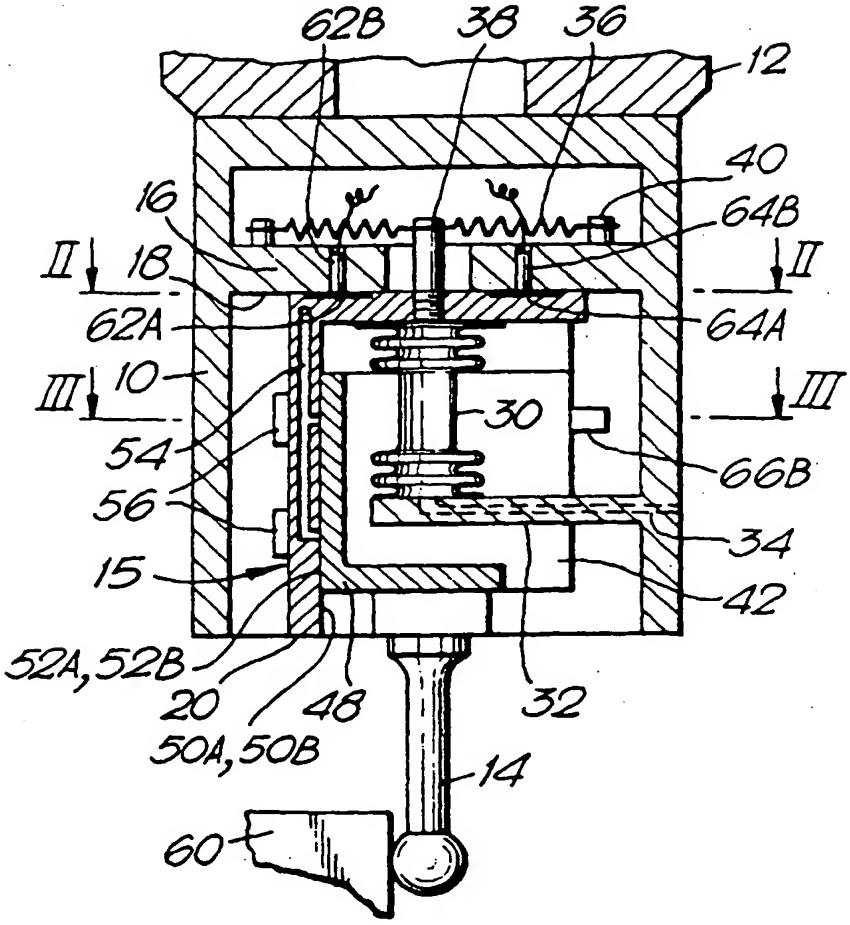
62B
38
36
12
40
16
64B
II
18
II
62A
64A
III
10
III
30
54
66B
56
34
15
42
52A, 52B
20
48
32
50A, 50B
14
60

Fig.2.

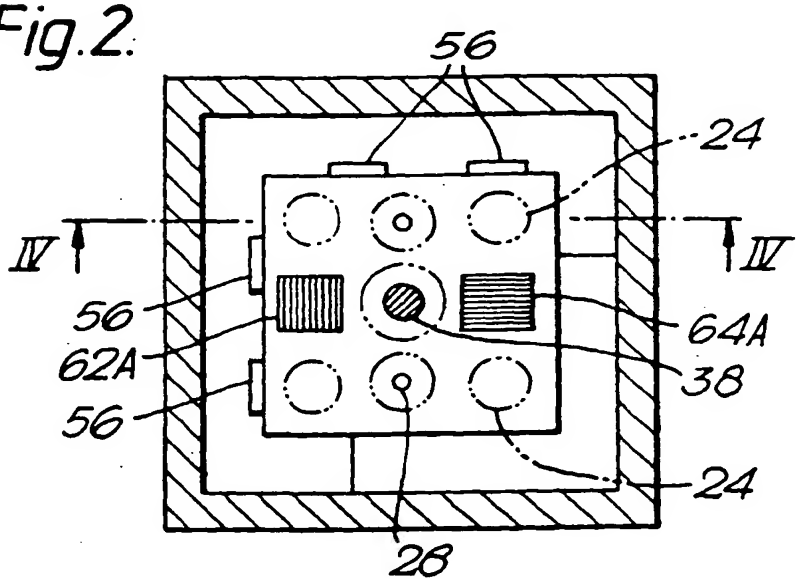
56
24
IV
IV
56
64A
62A
38
56
24
28

Fig. 3.

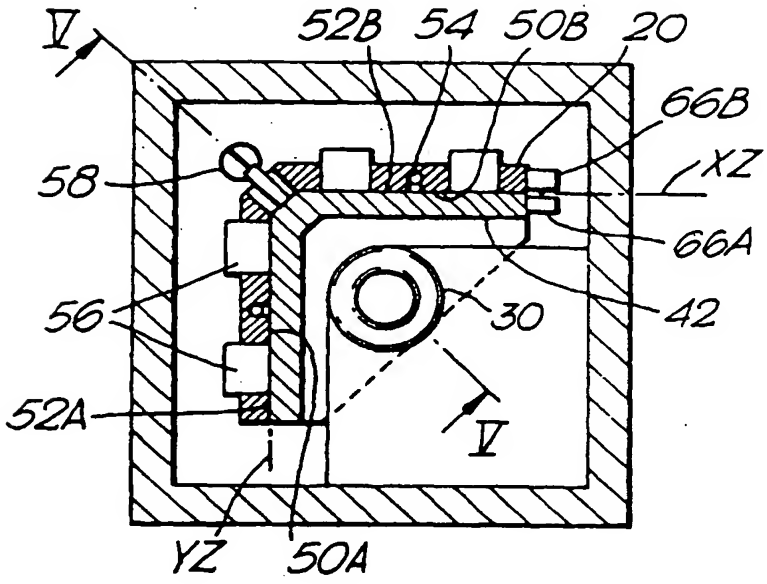

Fig. 4.

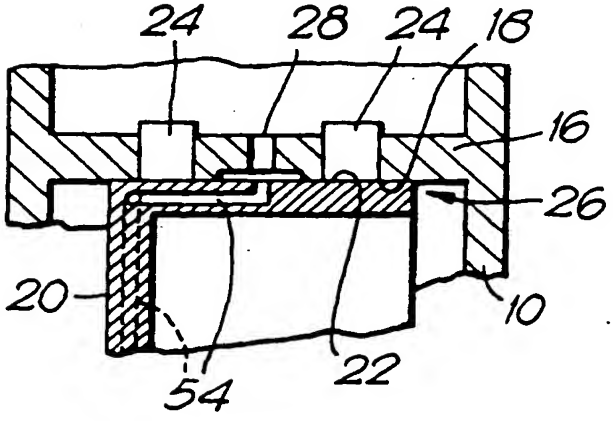

Fig. 5.

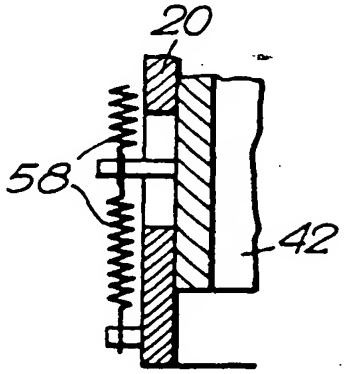

Fig.6.

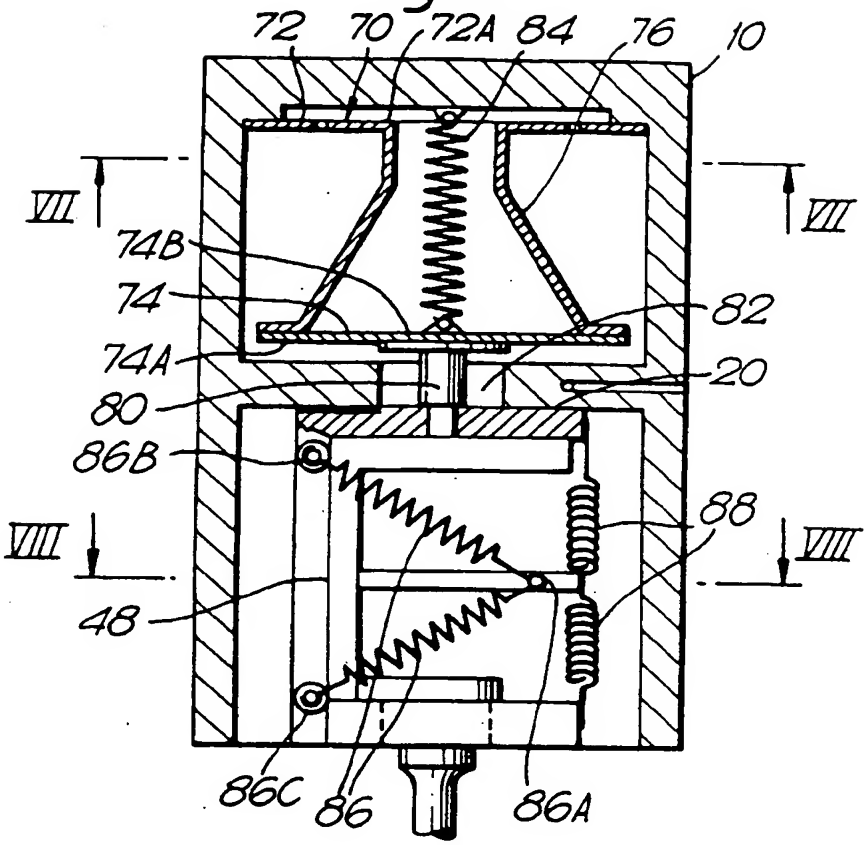

Fig.7.

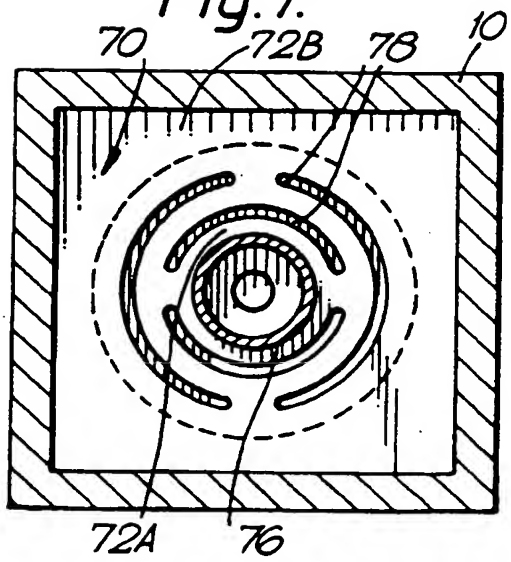

Fig.8.

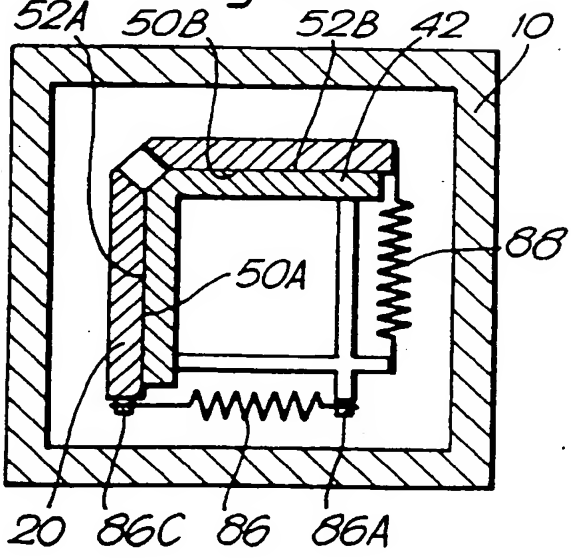

Fig.9.

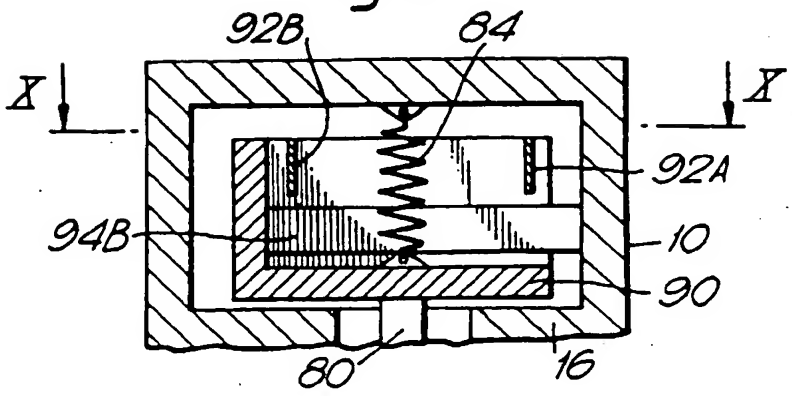

Fig.10.

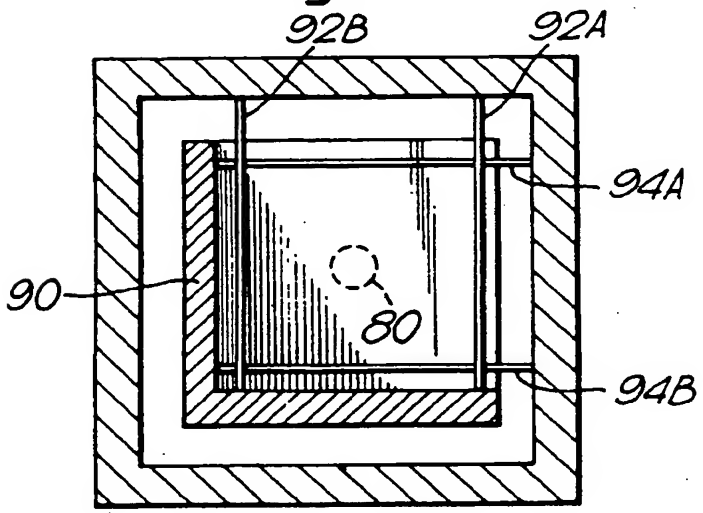

Fig.11.